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TOPOGRAPHIC MAPPING

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The Virginia Division of Mineral Resources and the Topographic Division, U. S. Geological Survey, entered into an expanded cooperative agreement on July 1, 1962, to provide adequate topographic map coverage for the entire State. These maps will be compiled by modern photogrammetric and field techniques at a scale and contour interval appropriate for showing significant topographic details. In Virginia, and in areas of similar topography, an "adequate" map has a scale of 1:24,000, has 90 percent of the well-defined planimetric points plotted in correct position on the map within 1/50th inch, and has 90 percent of the contours accurate within half a contour interval.

At the present time, only 12.3 percent of Virginia is covered by adequate topographic maps. Forty-nine percent of the State is now in the process of being mapped, 43.3 percent under the cooperative program and 5.7 percent under an all Federal program (Figure 1). Approximately three years are required to produce a finished topographic map. Coverage for Virginia is planned in the Atlantic Region office of the Topographic Division of the U. S. Geological Survey in Arlington. This includes cost analysis, pro-

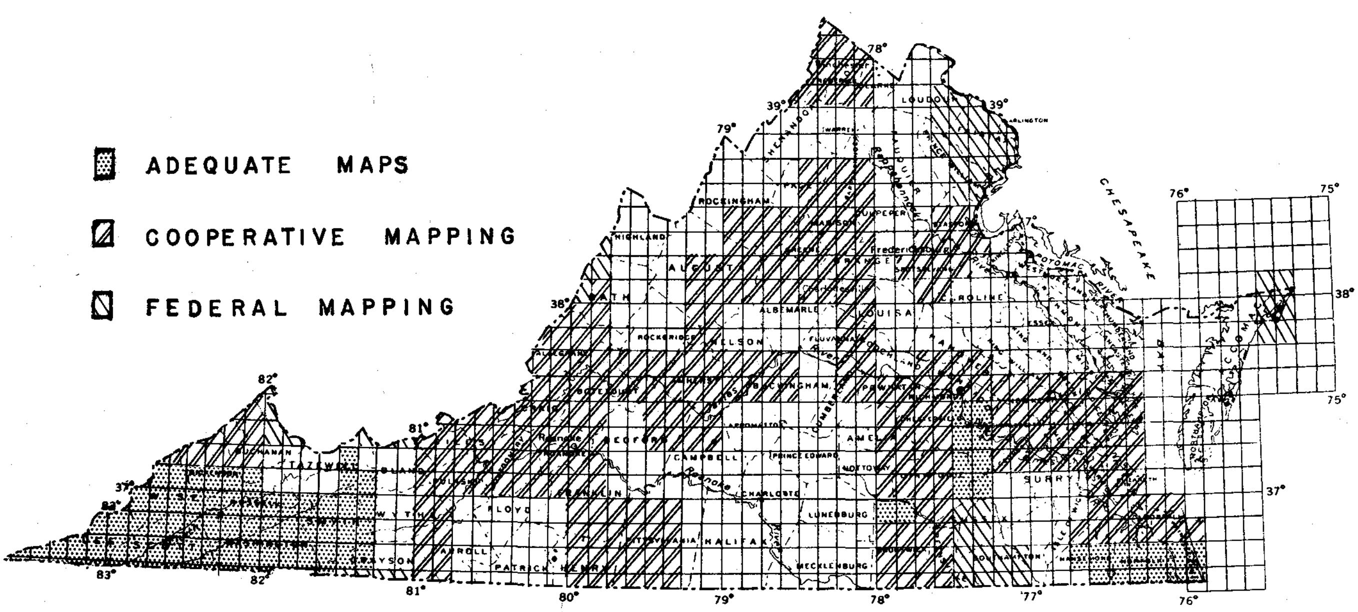

Figure 1. Topographic mapping program, 1962 - 1963.

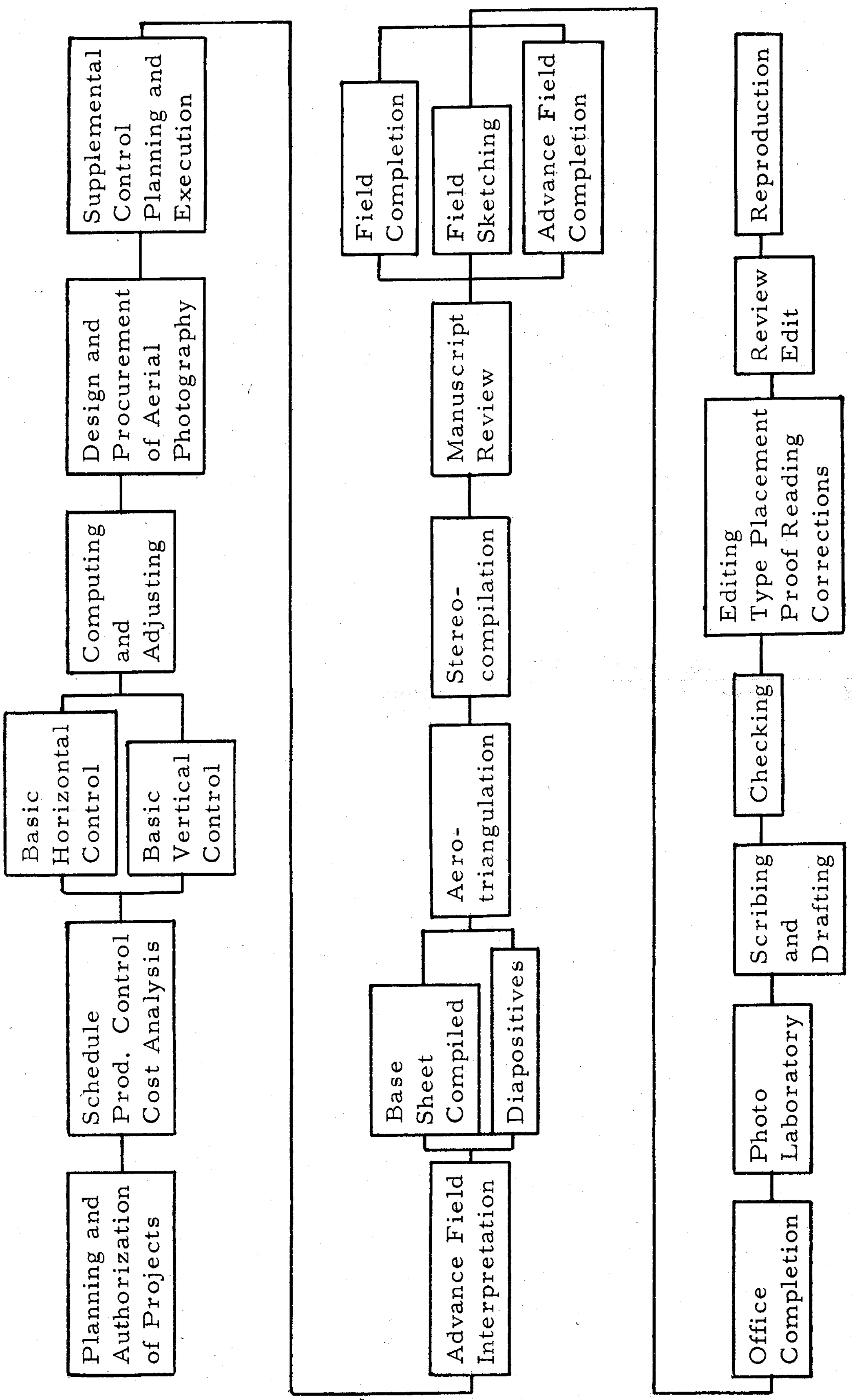

Figure 2. Flow sheet of topographic mapping procedures.

duction schedules, and the planning of basic control, contour interval, and map scale. The different phases in topographic map making are outlined (Figure 2).

Basic Control

The establishment of basic control is divided into two phases, horizontal control and vertical control. In the horizontal control phase the exact position is noted for photoidentifiable features or points near the corners of each $7\frac{1}{2}$ minute quadrangle that is being mapped topographically. Such features are those that can be recognized on aerial photographs. In the vertical control phase elevations are established at photoidentifiable points throughout the quadrangle. Basic control may be tentatively recorded either before or after the procurement of the aerial photography.

Horizontal Control

The measurement of the horizontal distance between features permits the photogrammetrist, or map maker, to accurately plot all physical and cultural features in their correct relative positions on a horizontal plane. The minimum number of points required for a $7\frac{1}{2}$ minute quadrangle is four, one in each corner. However, the number of points may be increased depending on the direction of flight strips, the height of flight, the type of photography, and the method of aerotriangulation.

Two methods are used to establish horizontal control, 1) transit traverse and 2) triangulation. Visibility between features generally governs the selection of the method to be used. Transit traverse is generally the more economical method of establishing horizontal control in flat areas with dense forest cover and other areas not suited for triangulation. The method also is used to check the stereocompilation and to train personnel. Determination of the horizontal location of well-defined topographic and planimetric features is made by measuring the horizontal distance and the compass direction between two features and a point of known location. The traverse accuracy must be within a range of ± 1 inch in 5,000 inches for the distance and ± 5.0 seconds of a degree for the compass direction.

A second method of establishing horizontal control is by triangulation. The survey is carried out using a transit theodolite with or without electronic devices for measuring distance. The electronic devices are used to measure the distance directly from a given location in a quadrangle to its four corners, and the compass directions and star shots are taken with a transit theodolite. When only a transit theodolite is used additional information, such as extra points and star shots, and a base line measurement, is needed to compile a net of connected triangles. From this triangulation net the position of the corners of the quadrangles can be computed. The difference between the computed and measured length of the baseline must be less than 1 inch in 5,000 inches and the average triangle closure must be less than 6.0 seconds of a degree.

Two general types of electronic instruments are used by the Topographic Division, U. S. Geological Survey to measure distance. The most widely used type operates on the principle of microwave transmission. Three instruments, the tellurometer, the electrotape, and the hydro-disc, are in use at the present time. These instruments have an accuracy of about 2 inches ± 3 parts per million. A distance of 10 miles is measured within ± 2 inches of its actual length. The second type of electronic instrument operates on the principle of transmitting and receiving reflected light waves. This instrument, the geodimeter, is used at night to obtain optimum reflection data. The accuracy of the geodimeter is ± 2 centimeters.

Vertical Control

The measurement of the elevation of photoidentifiable points is needed so that the photogrammetrist can accurately compile a contour map of an area. Vertical control is divided into two phases, primary and supplemental. Primary vertical control involves the establishment of a network of elevation marks along roads to which supplemental control points can be tied. These marks are left approximately every half mile at a photoidentifiable point. Bench marks are set every two to three miles. The elevations of all photoidentifiable points along a traversed road are marked on aerial photographs and are used in contouring the stereocompilation. Closures for primary control must be less than 0.05 feet times the square root of the length of the traverse in miles.

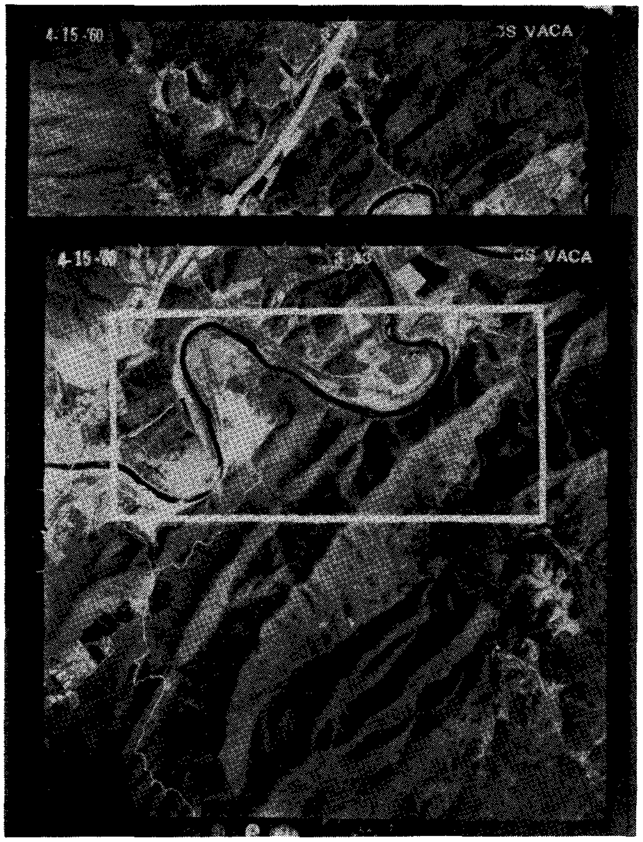

Figure 3. Stereoscopic model-area outlined by white line.

In the supplemental vertical control phase, the elevation of at least one photoidentifiable point near each corner of a model is measured. A model is the stereoscopic image produced by the overlapping areas of two adjacent aerial photographs (Figure 3). The elevations of the supplemental points are obtained by plane table methods. A traverse line is run from an elevation mark to the required photoidentifiable point. "The elevations of supplemental vertical control points must be accurate within one-tenth of the contour interval for intervals of 25 feet or less. For intervals of 40, 50, 80, and 100 feet the accuracy limits are 3, 4, 5, and 6 feet" (U. S. Geological Survey, 1955, p. 6).

In some areas where triangulation is used to determine horizontal control, the vertical control network may be established. This use of the triangulation method serves to reduce costs.

In the last three or four years the elevation meter has proved useful in establishing supplemental control in areas with a dense network of passable roads. This meter is a sensitive vehicle-borne device for measuring differences of elevation along a traversed route (Speert, 1962, p. 141). In an eight-hour day 30 to 50 miles can be covered. The elevations are accurate within 1 to 2 feet.

The elevation meter consists of a 4-wheel-drive, 4-wheel-steer vehicle, on which is mounted a calibrated fifth wheel to measure distance and a pendulum to measure slope (Virginia Division of Mineral Resources, 1959, p. 5). An automatic printing recorder prints the following information for each station at the push of a button: 1) the station designation, 2) the elevation of the starting point on the line, 3) the change in elevation, 4) the elevation of the new point, and 5) the distance from the starting point.

Photography

Two types of aerial photography are used: vertical, generally in areas of high relief; and convergent, generally in areas of low relief. In vertical photography the optic axis of the camera is perpendicular to the ground. For convergent photography the optic axis of the camera is inclined 20° from the vertical.

Once the type of photography is decided, detailed plans are completed for flight direction, flight line spacing, and flight height. Factors considered in this planning are the relative relief of the area, contour interval, shape of the area to be flown, season of the year, and the instrument to be used for stereocompilation. Aerial photographs are taken on relatively clear days at least three hours after the sun is above the horizon, and when no leaves are on the trees, and, in general, no snow on the ground.

Aerotriangulation

After the aerial photographs are obtained the next step in map production is aerotriangulation. The relative horizontal position of each photograph is established. Four horizontal control points on each model are required by the stereoplotters to establish a stereoscopic model. These photoidentifiable control points near the corners of a model are plotted on the aerial photographs and a template is made of two adjacent models. All the templates are joined together to provide the necessary supplemental horizontal control. After these templates are used to check correct alignment of aerial photographs, the stereocompilation can be made.

Stereocompilation

Either of two instruments is generally used to prepare a stereocompilation, the ER-55 plotter or the Kelsh plotter. A stereocompilation is the compilation of contours and planimetric features on a base sheet from a projected stereoscopic model. By direct photographic projection of overlapping aerial photographs an optical model of the terrain to be mapped is produced. The optical model is an image made by exact orientation of diapositives, aerial photographs printed on glass plates, to duplicate the orientation of the aerial camera at the instant of exposure during flight. The diapositives are projected through complimentary color filters, one red and the other blue-green. Thus, when the projected image is viewed with special glasses, the model appears three dimensional. By means of a "floating" mark on a tracing table platen the contours and planimentry can be drawn on a base sheet. A blue line print of the "before field completion" sheet of the stereocompilation is available for purchase from the Topographic Division, U. S. Geological Survey, 1109 North Highland St., Arlington, Virginia, at $0.50 a copy.

Field and Office Completion

Any stereocompilation prepared from aerial photographs is incomplete in that road, building, and drainage classifications, civil boundaries, and names are not included. The field completion party checks the quality and completeness of the stereocompilation, makes necessary additions or deletions, maps incompleted areas, and adds supplementary contours where needed.

After a map has been field completed it is reviewed and the corrections are compiled. From this compilation a blue line print of the "after field completion" sheet is available for purchase from the Topographic Division at $0.50 a copy.

Cartography and Editing

Throughout the cartographic process the manuscripts are checked periodically to assure that the information presented is accurate, complete, and conforms to accepted standards. This information includes examination of drainage patterns, contour treatment, names, and determination of the quadrangle name. All data to be shown on the map are verified by the editor. This material is then furnished the scribers, who prepare the overlays. An overlay is scribed for each color to be printed on the final map. These sheets are then carefully checked to assure that one color does not interfere with another. After the composite proof has been finished it is carefully reviewed and submitted for publication. A blue line print of the composite is available for purchase before the final review editing from the Topographic Division at $0.50 a copy.

The status of the various phases of topographic mapping are noted on a progress map (Figure 4).

Where to Purchase Topographic Maps

Published maps may be purchased by mail or over-the-counter from the U. S. Geological Survey, 1028 GSA Building, 19th and F Streets, NW, Washington 25, D. C. and the Virginia Division of Mineral Resources, P. O. Box 3667, University Station, Charlottesville, Va. The U. S. Geological Survey charges $0.30 per map but allows a 20 percent discount on orders of $10 or more. The Division of Mineral Resources allows no discount and limits orders to six copies of any one map. An Index to Topographic Mapping in Virginia is available upon request, at no charge, from either agency.

Preliminary maps and published maps are available from the Topographic Division, U. S. Geological Survey, 1109 N. Highland Street, Arlington. The charge for preliminary maps is $0.50 per copy and no discount is allowed for quantity purchases.

The following agents in Virginia carry some of the published maps available in the Commonwealth and sell them at prices usually slightly higher than those charged by the U. S. Geological Survey or the Virginia Division of Mineral Resources.

IRVINGTON:
Willings
LYNCHBURG:
J. P. Bell Co., 816 Main Street
NEWPORT NEWS:
E. Smola Co., 134 Twenty-fifth Street
NORFOLK:
Henry Eagleton Co., 430 Boush Street
RICHMOND:
Everett Waddey Co.
1105 East Main Street
1627 Willow Lawn Drive
614 West Southside Plaza
ROANOKE:
Malcolm Blue Print and Supply Co.
632 Second Street, SW, P. O. Drawer 1178

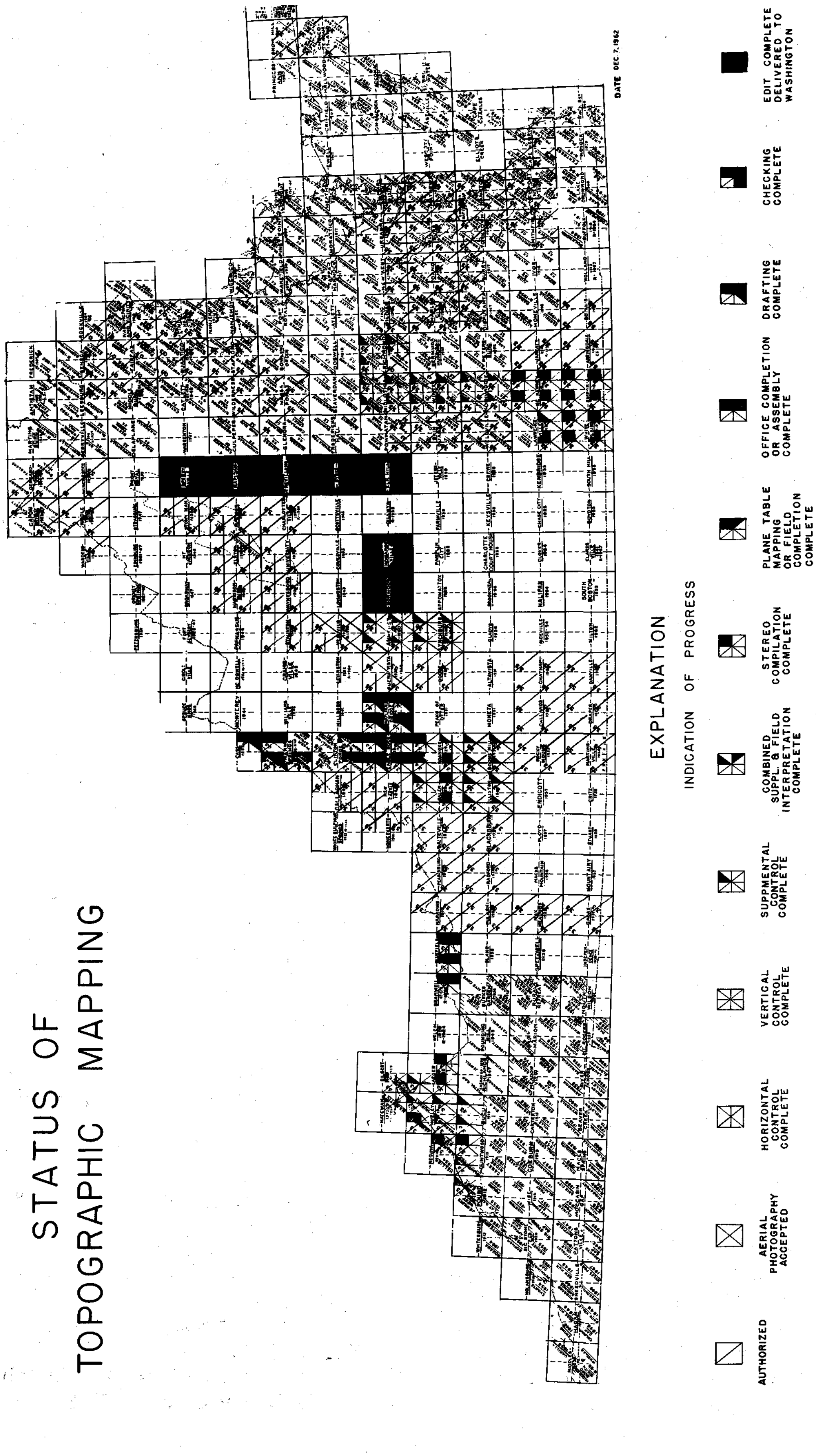

Figure 4. Progress of topographic mapping.

References

Speert, J. L., 1962, New Elevation Meter for Topographic Surveys: U. S. Geological Survey Prof. Paper 450-B, p. 141-142.

U. S. Geological Survey, 1955, Triangulation Planning and Reconnaissance: Geological Survey Topographic Instructions, Book 2, Part 2A, Chapter 2, 17 p.

Virginia Division of Mineral Resources, 1959, Topographic Mapping in Virginia: Virginia Minerals, vol. 5, no. 3, 8 p.

New Developments

The Dominion Minerals Division of the Riverton Lime and Stone Company discontinued grinding and processing aplite at their plant near Piney River, Nelson County, in December 1962. The processed aplite was utilized in the glass and ceramic industries. The Company will continue to quarry rock at this location for crushed stone purposes.

The merger of the Metal and Thermit Corporation and the American Can Company became effective on December 19, 1962. Metal and Thermit Corporation has been organized into a subsidiary named Metal and Thermit Chemicals, Inc. The management of the quarry and ore processing plants at Beaverdam, Hanover County, Virginia, will remain the same. The Company is engaged in the mining of aplite, for use by the glass industry, and titanium concentrates (rutile and ilmenite).

The Eagle Rock Limestone Corporation began quarrying limestone from a location near Eagle Rock, Botetourt County, during 1962. The stone will be utilized primarily as crushed stone for road aggregate.

The Velvet Sand Company located near Ironto, Montgomery County, was purchased in November, 1962, by the Montgomery Limestone Corporation, a subsidiary of B. R. deWitt, Inc., Pavilion, New York. Operations of the quarry and plant, to be known as the Ironto Sand Company, will be continued for the production of crushed sandstone for general construction purposes. The Montgomery Limestone Corporation has discontinued operations at their New River limestone quarry located near Dublin, Pulaski County.

The Mineral Industry of Virginia in 1962[1]

Value of mineral production in Virginia in 1962 rose to $229 million, a new high, slightly above the previous record year 1957, and 3 percent higher than in 1961, according to estimates by the Bureau of Mines, United States Department of the Interior. Contributing chiefly to the increase over 1961 was the moderate rise in the output of bituminous coal. A vigorous construction industry resulted in stone and sand and gravel production only slightly less than in 1961, the record year in Virginia for those minerals.

Mineral Fuels

Production of bituminous coal totaled 32.6 million short tons, a record tonnage, 7 percent higher than the former high in 1961. The value of coal output also established a new high and as in most recent years represented more than 50 percent of the total value of Virginia's mineral output. Production and value of petroleum and natural gas, largely for local consumption, were higher than in 1961. Production of mineral fuels is centered in 7 southwestern Virginia counties. A battery of Mitchell nonrecovery-type coke ovens are to be completed near Vansant, Buchanan County, and scheduled to be in operation early in 1963.

Nonmetals

Production of stone in 1962 was nearly equal to that of 1961 and output of sand and gravel was only 3 percent under 1961, indicating an active construction year. Output and value of other materials used largely in construction—clay, lime, gypsum, and masonry cement—all were greater than in the previous year. The rise in gypsum output was partly due to the opening of a new mine near Saltville. Portland cement, the third highest commodity in Virginia in terms of value, was only 3 percent below 1961. Values of crushed limestone, crushed granite, and dimension slate production were higher than in 1961. Value of output of kyanite and feldspar, used mostly in ceramic manufacture, was about the same in 1962 as in the previous year. Quantity and value of salt recovered from southwest Virginia brines

1. Prepared December 14, 1962 by Robert W. Metcalf, Mineral Specialist under the supervision of Samuel A. Gustavson, Chief, Pittsburgh Office of Mineral Resources, Region V, U. S. Bureau of Mines. From Area Report H-221.

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increased somewhat while output of pyrites from the Gossan Lead in Carroll County was discontinued at the end of the first quarter of 1962.

Metals

Output of lead, zinc, and titanium concentrate (ilmenite and rutile) was less than in 1961, and the average value per ton of lead dropped 11 percent. The average value per ton of titanium concentrate, however, was higher than in 1961. Production and value of iron oxide pigments increased substantially.

TABLE 1. Mineral production in Virginia

Mineral	1961 Quantity	1961 Value (thousands)	Preliminary 1962 Quantity	Preliminary 1962 Value (thousands)
Aplite .... thousand long tons	97	$ 651	138	$ 956
Clays .... thousand short tons	1,406	1,332	1,449	1,443
Coal (bituminous) .... do	30,332	126,121	32,590	(2)
Gem stones	(3)	6	(3)	6
Lead (recoverable content of ores, etc.) .... short tons	3,733	769	3,678	677
Lime .... thousand short tons	739	8,596	775	9,010
Natural gas .... million cubic feet	2,466	668	2,500	700
Petroleum (crude) .... thousand 42-gallon barrels	2	(2)	3	(2)
Sand and gravel .... thousand short tons	9,839	14,697	9,500	14,150
Stone .... do	22,934	39,206	22,724	38,917
Zinc (recoverable content of ores, etc.[4]) .... short tons	29,163	6,726	26,462	6,086
Value of items that cannot be disclosed: Cement (portland and masonry), feldspar, gypsum, iron ore (pigment material), kyanite, mica (sheet), pyrites, salt, soapstone, titanium concentrate (ilmenite and rutile), and values indicated by footnote [2]		27,747		161,629
Total Virginia [5]		221,825		228,818

1. Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2. Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."
3. Weight not recorded.
4. Recoverable zinc valued at the yearly average price of prime western slab zinc, East St. Louis market. Value established after transportation, smelting, and manufacturing charges have been added to the value of ore at the mine.
5. Total adjusted to eliminate duplicating value of clays and stone.